IUE OBSERVATIONS OF VARIABILITY IN WINDS FROM HOT STARS

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ABSTRACT

Observations of variability in stellar winds or envelopes provide an important probe of their dynamics. For this purpose a number of O, B, Be, and Wolf-Rayet stars have been repeatedly observed with the IUE satellite in high-resolution mode. In the course of analysis, instrumental and data handling effects were found to introduce spurious variability in many of our spectra. Software has therefore been developed to partially compensate for these effects, but limitations remain on the type of variability that can be identified from IUE spectra. With these contraints, preliminary results of multiple observations of two OB stars, one Wolf-Rayet star, and a Be star are discussed.

TEXT

Observations of variability in stellar winds or envelopes provide an important probe of their dynamics. IUE, with its ability to simultaneously sample large portions of the ultraviolet spectrum, can potentially enable one to relate temporal variations in one spectral feature to other lines. Ultimately this may yield a spatial as well as spectral probe of the outer atmospheres of hot stars. Before any such analysis can be undertaken, however, it is essential to determine the type and amplitude of variability which can be measured from IUE high-resolution spectra.

Reduction and analysis of IUE high-resolution data for temporal variability is complicated by a number of instrumental and data handling effects which can introduce sufficient spurious variability into the spectra to swamp any real stellar variability. These effects and programming to partially compensate for them developed on the PDP 11/34 of LASP/University of Colorado using the Interactive Data Language are discussed by Grady (1). Limitations do remain on the amplitude of line profile variations that IUE is capable of detecting in high resolution. For example, in order to compensate for differing exposure times and positioning of the target star in the spectrograph slit, all of our data has been normalized to the continuum = 1. As a result, it is impossible to monitor changes in continuum level. Thus, our effort has been concentrated on changes in profile shape and relative intensity in a number of lines known to indicate mass loss. (2)

It is then necessary to determine the changes in relative flux which can be confidently attributed to the star, rather than the instrument and subsequent data handling. One of the stars in our variability search, α Cam (HD 30614, O9.5Iab) showed no evidence of any change in its P Cygni profiles to the limits imposed by noise in the data when observed nearly continuously for three days in September, 1978, for a total of 75 exposures, when reobserved once a month later, and again in January of 1979. For this reason, this

star has been chosen to determine the noise limits in different parts of the SWP spectrum. Only SWP spectra are considered in this paper, as we are still awaiting our reprocessed LWR spectra. Table 1 gives the limits on change in relative flux level as a percentage of the zero to continuum level. To be confident that the change in flux level is stellar, rather than instrumental or processing-induced, the further constraint has been imposed that the change in the flux level must be sustained over a 0.1Å interval. Changes over smaller intervals may be real, but a detailed examination of gross and background records for each image would be essential in order to determine whether or not this is the case.

OBSERVATIONS

Even with these conditions, three stars surveyed to date show clear evidence of temporal variations in their P Cygni profiles. Analysis is still in the preliminary stages for all three. They are κ Cas (B1Ia, HD 2905); 59 Cygni (Be, HD 200120) and γ^2 vel (WC8 + 09I, HD 68273).

κ Cas was observed as part of a cooperative program with H.J.G.L.M. Lamers, C. deJaeger, and F. Machetto. It was observed for 29 hours in alternation with α Cam on Sept. 9-10, 1978. A total of 26 SWP high-resolution exposures were made during this time with exposure times of 6-10 minutes. All profiles were constant to within the limits of detection. On Oct. 12, 1978 a single exposure of κ Cas was obtained. The fully-saturated P Cygni profiles showed no changes in shape or relative intensity beyond the noise limits. The two unsaturated profiles, CII λ1335, and AlIII λ1854, λ1862 did show noticeable changes. The CII P Cygni profile appears slightly broader in the October spectrum than in the Sept. data. It was not possible to measure the edge velocity for this line as the profile lacks a sharp short wavelength absorption edge. The changes in the AlIII profile are much larger. In the September observations only the AlIII λ1854 line has a well developed Type I P Cygni profile (see Fig. 1). A saturated emission feature is present at the wavelength expected for the λ1862 emission. Weak absorption is present shortward of this feature. In the October observation both AlIII components are clearly present, although the λ1862 line suffers from an instrumentally saturated emission peak. The emission part of the λ1854 profile appears to be about the same as in September. Likewise, the edge velocity, as measured from the λ1854 line, appears to be constant. The striking changes in the absorption component occurs at the red side of the absorption feature, in the velocity range -(410-710) ±20km/sec.

59 Cygni was observed in cooperation with V. Doazan, R.N. Thomas, L. Kuhi, and J.M. Marlborough. Data has been processed at LASP only for observations made in June and September of 1979. Data handling problems have prevented analysis of all ions with the exception of CIV λ1548.188, λ1550.762. (See Fig. 2) In June, 1979 the doublet is blended together in absorption. The profile appears to be saturated. By September, however, both components are clearly visible. How this correlates with changes in other orders is not yet known. A cursory examination of SiIV λ1400 indicates that no such drastic changes occurred for that ion.

γ^2 vel was observed as part of a collaborative program involving K.A. van der Hucht, A. Willis, F. Machetto, R. Wilson, and D. Stickland with some of the data analysis taking place at C.U. We have processed CIII λ1176, SiIII λ1206, NV λ1240, CII λ1335, SiIV λ1400 (Fig. 3), CIV λ1550 (Fig. 4), and NIV λ1718. All of the ions surveyed show some changes in the shape of the absorption part of the P Cygni profile. More dramatically, all show decreased emission at phase 0.53 of the binary orbit. At this phase the Wolf-Rayet star is in front as seen from Earth. With data covering only one orbital period it is impossible to be certain that this decrease is related, but the data are rather suggestive.

CONCLUSIONS

Despite the limits on the amplitude and type of temporal variability that can be confidently detected using IUE in high-resolution mode, it is possible to observe significant time variations in the P Cygni profiles of hot stars.

REFERENCES

1. Grady, C.A.: Problems and Programming for Analysis of IUE High-Resolution Data for Variability. The Universe in Ultraviolet Wavelengths: The First Two Years of IUE. NASA CP-2171, 1980: this compilation.
2. Snow, T.P. Jr. and Morton, D.C.: Ap J Supp Ser, vol. 32, 1976, pp. 429-465.
3. Niemelä, V.S. and Sahade, J.: The Orbital Elements of γ^2 Velorum, preprint Sept. 1979.

TABLE 1

Ion	Wavelength	Noise (as % of continuum level)
CIII	1175.67	∿100
SiIII	1206.51	∿ 60
NV	1240	35 ± 4
SiIV	1398	20 ± 3
CIV	1549	19 ± 2
NIV	1718.551	15 ± 2

Percentage change in flux level which must be exceeded in a given P Cygni profile to be confident that any variations are stellar rather than instrumental. In all cases the data has been normalized to continuum = 1.

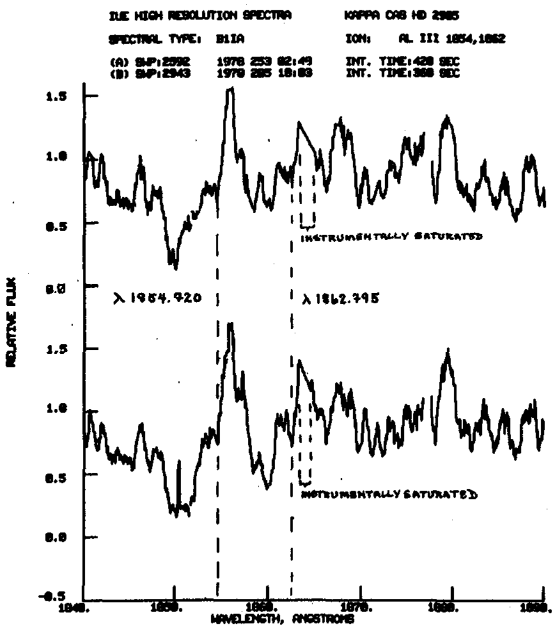

Fig. 1. κ Cas observed (upper spectrum) Sept. 9, 1978 and (lower spectrum) Oct. 12, 1978 in AlIII λλ1854, 1862. Note the change in the absorption.

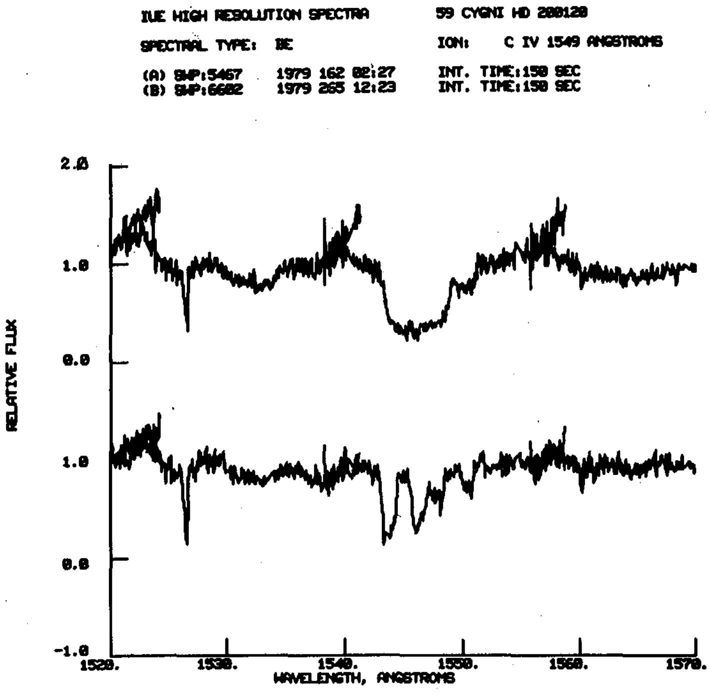

Fig. 2. 59 Cygni observed (upper spectrum) June 10, 1979 and (lower spectrum) Sept., 1979 in CIV.

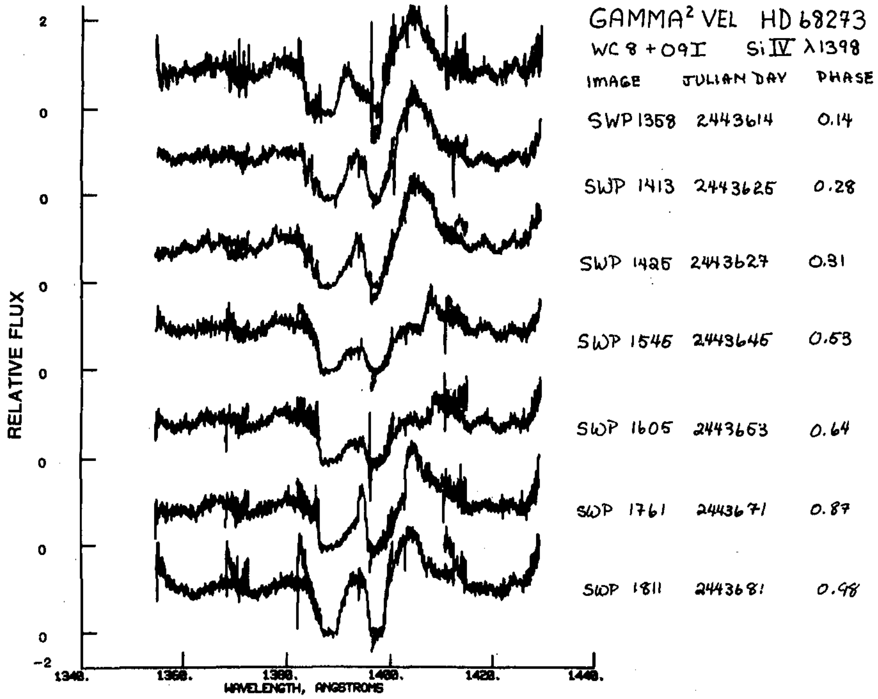

Fig. 3. γ^2vel: Observations at different phases in 1978 of SiIV λ1398. Phases calculated from (3).

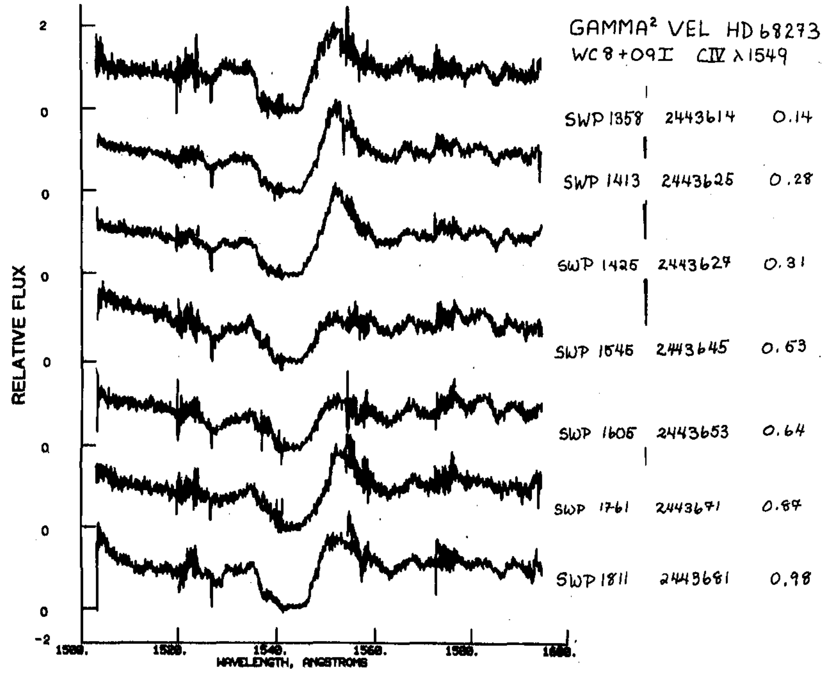

Fig. 4. γ^2vel: Observations at different phases in 1978 of CIV λ1549.